Portraits of Sir B. C. Brodie and the Rev. T. Eagles, and Sketch of a Poor Irish Girl, by J. Z. Bell, Esq.

15 Ammonites from the Secondary Formations, Exhibited by Mr. Tennant; and an Engraving of the "Ammonites Heterophyllus," presented by him to the Royal Institution Library.

Mr. Varley showed by the Microscope the beating of the heart in the Monoculi and Wheel-animalcules.

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## WEEKLY EVENING MEETING, 39.

Friday, May 21.

W. R. Grove, Esq., M.A., F.R.S., Vice-President, in the Chair.

B. C. Brodie, Esq.

*On the Allotropic Changes of Certain Elements.*

The earliest conception of the nature of a chemical substance was limited to the knowledge of the ultimate or elemental particles into which it could be broken up. To this after a time was added that of the proportion in which these elements were combined. But this too proved inadequate to explain the chemical differences of bodies, especially their dynamic differences, that is, the different modes of change of which they are susceptible—why for example, from certain bodies containing many atoms of hydrogen, one of these atoms can readily be removed and replaced by a metal, while no skill has yet effected a similar exchange with a second. The progress of discovery, moreover, established beyond a doubt the existence of a class of bodies consisting of the same elements, combined in the very same proportions, which yet differed in their chemical and physical properties. To meet these and other difficulties, gradually arose an idea new to chemical science, the idea of structure or *chemical form*, in the elaboration of which, chemists of late years have been principally engaged. The way in which this conception has been applied to explain the relation of isomeric bodies may be seen by the following illustration. Representing water as $\begin{matrix} H \\ H \end{matrix} O$, alcohol is represented as $\begin{matrix} C_2 & H_5 \\ & H \end{matrix} O = C_2\ H_6\ O$, and methylic ether as $\begin{matrix} C_2 & H_3 \\ C_2 & H_3 \end{matrix} O. = C_2\ H_6\ O.$ This last substance is identical with alcohol in its elemental constitution, but differs from it in its

chemical reactions. This difference is expressed by assuming that the hydro-carbon is differently distributed in the two substances. Looking at the above formulæ, it will be perceived that the conversion of the one substance into the other would be effected by the transference of hydro-carbon from one to the other part of the system. The change in this case has not yet been effected; but in certain other instances we are enabled to effect very analogous transformations, and to recombine the particles in the interior, as it were, of the body itself.

One or two instances were shown of this isomeric metamorphosis, which were so selected as to illustrate the modes by which it could be effected. For example—styrol, (an oil procured by the distillation with water of the liquid storax), by the application of heat, is converted without either the addition or the loss of any chemical substance into a transparent solid, in its ultimate constitution identical with the oil. The formula of the oil is $C_8\ H_8$, that of the solid according to Blyth and Hofmann, who first made it a subject of investigation, $C_7\ H_7$.

In certain cases these changes may be brought about by a chemical action very analogous to that of fermentation, by which sugar is converted without alteration of weight into carbonic acid and alcohol. There is a body called aldehyde, $C_2\ H_4\ O$, a very volatile substance boiling almost with the warmth of the hand, and the vapour of which is about $1\frac{1}{2}$ times as heavy as air. By the addition of one drop of sulphuric acid it is converted into a body which boils at a higher temperature than water, and the vapour of which is $4\frac{1}{2}$ times as heavy as air. Our knowledge is too imperfect to state the precise mode in which the elements are re-arranged, but from the density of the vapour we infer that the molecule of the transformed aldehyde contains three times the number of atoms of the original body and is $C_6\ H_{12}\ O_3$. Oil of turpentine is in a most remarkable degree susceptible of these metamorphoses. By the action of sulphuric acid it is converted into oils, isomeric with it, but each differing from it in some one or more properties. Great heat is evolved during the change, due doubtless to the chemical combination which is taking place. In certain cases, as, for example, the formation of paracyanogen by the decomposition of cyanide of silver, this heat is so great as to cause the vivid ignition of the substance.

Acquaintance with these facts is necessary to view in their scientific connexion certain phænomena of the elemental bodies which go under the name of *allotropy*, and which are to them, precisely what isomeric phænomena are to compound substances. This allotropy has been observed in the case of many elements, carbon, boron, silicon, selenium, sulphur, phosphorus, arsenic, and possibly oxygen—from these sulphur and phosphorus were selected as presenting points of peculiar interest.

At a few degrees above the boiling point of water, Sulphur

melts to a transparent yellow fluid ; at about 160° C. it changes in appearance, becoming red, and between 220° and 250° C. it becomes deep red and viscid. Heated beyond this point it again becomes liquid, and just before it boils appears as a deep black fluid. These changes in the sulphur have been connected with certain thermic phænomena, which leave no doubt but that they are truly transitions from one allotropic form to another. During cooling, sulphur passes through the same changes, but in an inverse order; and it has been observed that the sulphur does not cool by regular gradation, but that at certain points its temperature is stationary, or falls much slower than at other points; this can only be explained by assuming a developement of heat from the sulphur itself, which compensates for that which it loses ; and this developement of heat takes place just about the points of transition from one state to another. By cooling suddenly the viscid sulphur, it may be retained for a long time in the form of a transparent elastic substance, which ultimately solidifies to a sulphur differing in many respects from the ordinary modification of the body, especially in being in great measure insoluble in bisulphide of carbon.—An experiment was shewn of the reconversion of this peculiar sulphur into the viscid form ; this can be effected without melting the body by a proper regulation of the temperature.

It had been long known that Phosphorus exposed to sun-light assumed a red colour. Berzelius suspected this to be an allotropic modification of the element; and the experiments of Schrötter, who produced the same body by the action of heat, have established this view and enable us to procure this phosphorus in large quantities. In its chemical properties, as well as in appearance, this red phosphorus is entirely different from the ordinary modification.

The change thus produced by heat can also be effected by chemical agency. By the action of iodine ordinary phosphorus can be converted in large quantities into the allotropic modification. This can be done by projecting iodine into phosphorus melted under strong hydrochloric acid, or into phosphorus simply melted in a tube, and subsequently heating the substance. The iodine is employed in very small quantities. It first dissolves in the liquid phosphorus ; at a certain point as the temperature is raised a violent evolution of heat takes place, which causes a kind of explosion in the substance, and the mass of the phosphorus passes at this moment into the other condition. A small quantity of iodine will in this manner convert (if sufficient time be allowed) an absolutely unlimited quantity of phosphorus.*

On a former occasion certain experiments were shown as evidence that the formation of oxygen, and indeed of other elements, was a

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* The theory of this action and the detailed experiments are given in a Paper on the action of Iodine upon Phosphorus, read by the Author before the Chemical Society on the 21st of June.

chemical combination of particles of the same nature as the formation of a compound substance, and that the two classes of bodies had a similar molecular constitution.* By the phænomena of allotropy, other analogies are brought out between them, which lead to a similar belief. The similarity is so great between the facts in the two cases, — they are produced by the same means, by the alteration of temperature and by chemical action, — they are attended with the same evolution of heat, — that it is reasonable to refer them to the same cause. In the case of the compound substance we have the most direct evidence that the allotropic conversion is the re-combination of the particles of the substance and the transition from one chemical type to another. The inference is that the change in the case of the elements is of the same nature, and that phosphorus and sulphur are molecular groups capable of this re-arrangement and re-distribution.

[B. C. B.]

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In the Library were exhibited: —

Sulphur in its Native, Crude, Refined, Commercial, and Pharmaceutical Forms. [Exhibited by Mr. S. Highley, jun.]

Cardinal Wiseman, from the Bust by Mr. C. Moore, in Machine Sculpture, by Mr. Cheverton.

Various Groups in Parian. [Exhibited by Mr. Addey.]

Ancient Egyptian Ear ornaments; — Etruscan ear-rings, and sarcophagus; — Roman bulla, fibula, spoons, ear-rings; — Saxon clasps, fibula, and boss of shield; — Celtic gold armilla, and fibula; bronze armilla; silver armilla; Saxon portions of the Mancus, Cuerdale; — Ancient carvings in bone. [Exhibited by W. Chaffers, Esq., F.S.A.]

Testimonial (in Silver) to the 60th Rifles, by Major Moore. [Exhibited by Messrs. Hunt and Roskell.]

Portrait of Lady Bryant, by J. Z. Bell, Esq.

Minerals, and Sulphur Casts from R. I. Museum.

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* See on this subject the Author's Paper in the Philosophical Transactions, 1850, "on the Condition of certain Elements at the moment of Chemical Change."